CLAIMS

What is claimed is:

1. A fuel cell system, comprising:

a fuel cell stack;

an oxygen concentration sensor positioned proximate the fuel cell stack;

a hydrogen concentration sensor positioned proximate the fuel cell stack;

a stack temperature sensor positioned to monitor a temperature of the fuel cell stack;

a fuel cell stack current sensor coupled to measure a current through the fuel cell stack;

a fuel cell stack voltage sensor coupled across the fuel cell stack to measure a current across the fuel cell stack; and

a microcontroller coupled to the oxygen concentration sensor, the hydrogen concentration sensor, the stack temperature sensor, the fuel cell stack current sensor and the fuel cell stack voltage sensor to receive signals corresponding to an oxygen concentration reading of the oxygen concentration sensor, a hydrogen concentration reading of the hydrogen concentration sensor, a temperature reading to the stack temperature sensor, a current reading of the current through the fuel cell stack and a voltage reading of the voltage across the fuel cell stack, respectively, the microcontroller configured to compare the oxygen concentration reading to a oxygen concentration threshold value, the hydrogen concentration reading to a hydrogen threshold value, the temperature reading to a temperature threshold value, the stack current reading to a stack current threshold and the stack voltage reading to a stack voltage threshold on a predefined schedule during normal operation of the fuel cell system.

2. The fuel cell system of claim 1 wherein the microcontroller is configured to stop operation of the fuel stack in the case of at least one of:

the oxygen concentration reading is lower than the oxygen concentration threshold value;

the hydrogen concentration reading is greater than the hydrogen threshold value;

the temperature reading is greater than the temperature threshold value;

the stack current reading is greater than the stack current threshold; and

the stack voltage reading is greater than the stack voltage threshold.

3. The fuel cell system of claim 1, further comprising:

an air compressor positioned to pass air over the fuel cell stack, wherein the microcontroller is configured to vary a duty cycle of the air compressor in response to the stack current reading.

4. The fuel cell system of claim 1, further comprising:

an air compressor positioned to pass air over the fuel cell stack, wherein the microcontroller is configured to vary a duty cycle of the air compressor in response to the stack current reading and the hydrogen sensor is positioned downstream from the fuel cell stack with respect to the flow of air from the air compressor.

5. The fuel cell system of claim 1, further comprising:

a fuel cell voltage checking sensor coupled to a number of pairs of fuel cells to measure a voltage across each pair of fuel cells, wherein the microprocessor is further coupled to the fuel cell voltage checking sensor to receive signals corresponding a status of the fuel cells.

6. The fuel cell system of claim 1, further comprising:

a purge cell voltage checking sensor coupled to a purge cell to measure a voltage across the purge cell, wherein the microprocessor is further coupled to the purge cell voltage checking sensor to receive signals corresponding a purge cell voltage reading measured across the purge cell, and wherein the microcontroller is further configured to compare the purge cell voltage reading to an average fuel cell voltage based on the stack voltage reading.

7. The fuel cell system of claim 1, further comprising:

an air flow sensor positioned measure an air flow over the fuel cell stack, and wherein the microcontroller is further coupled receive a signal from the air flow sensor corresponding to the measured air flow over the fuel cell stack.

8. The fuel cell system of claim 1, further comprising:

an ambient air temperature sensor positioned proximate the fuel cell stack to measure an ambient air temperature proximate the fuel cell stack, wherein the microcontroller is configured to prevent a start up of the fuel cell system and to stop operation of the fuel cell system if the ambient air temperature proximate the fuel cell stack is below an air temperature threshold.

9. The fuel cell system of claim 1, further comprising:

a fuel pressure sensor coupled to a fuel delivery system of the fuel cell system to measure fuel pressure in at least one fuel tank, wherein the microcontroller is configured to prevent a start up of the fuel cell system and to stop operation of the fuel cell system if the fuel pressure is below a fuel pressure threshold.

10. A microcontroller configured to operate a fuel cell system, by:

performing a stack current check;

performing a stack voltage check; and

performing a cell voltage check on a predefined schedule during normal operation of the fuel cell system.

11. The microcontroller of claim 10 configured to perform the stack current check twice as often as the stack voltage check and twice as often as the cell voltage check.

12. The microcontroller of claim 10 wherein

performing a stack current check comprises:

receiving a stack current reading from a stack current sensor;

comparing the received stack current reading to a stack current threshold;

stopping operation of the fuel cell system if the received stack current reading exceeds the stack current threshold; and

varying a duty cycle of an air compressor in relation to an average of a number of the received stack current readings;

performing a stack voltage check comprises:

receiving a stack voltage reading from a stack voltage sensor;

comparing a stack voltage reading from a stack voltage sensor to a stack voltage threshold; and

stopping operation of the fuel cell system if the received stack voltage reading exceeds the stack voltage threshold; and

performing a cell voltage check comprises:

determining if any pair of fuel cells in the fuel cell stack has a voltage below a threshold cell voltage; and

stopping operation of the fuel cell system if any pair of fuel cells in the fuel cell stack has a voltage less than the threshold voltage.

13. The microcontroller of claim 10, further configured to operate the fuel cell system, by:

performing an oxygen concentration check, comprising:

receiving an oxygen concentration reading from an oxygen concentration sensor;

comparing the received oxygen concentration reading to an oxygen concentration threshold value; and

stopping operation of the fuel cell system if the received oxygen concentration reading is below the oxygen concentration threshold;

performing a hydrogen concentration check, comprising:

receiving a hydrogen concentration reading from a hydrogen concentration sensor;

comparing the received hydrogen concentration reading to a hydrogen threshold value; and

stopping operation of the fuel cell system if the received hydrogen concentration reading exceeds the hydrogen concentration threshold; and

performing a stack temperature check, comprising:

receiving at least one stack temperature reading from a stack temperature sensor;

comparing a stack temperature based on the received stack temperature readings to a stack temperature threshold value; and

stopping operation of the fuel cell system if the received stack temperature reading exceeds the stack temperature threshold.

14. The microcontroller of claim 10 where stopping operation of the fuel cell system includes at least one of stopping operation during a startup mode and stopping operation during an operating mode.

15. The microcontroller of claim 10, further configured to operate the fuel cell system, by:

performing a purge check, comprising:

receiving stack voltage reading from a stack voltage sensor;

determining an average fuel cell voltage from the stack voltage;

receiving a purge cell voltage from a purge cell sensor; and

comparing the purge cell voltage to the average fuel cell voltage; and

stopping operation of the fuel cell system if the purge cell voltage is less than a defined percent of the average fuel cell voltage.

16. A computer-readable media having instructions for causing a microcontroller to operate a fuel cell system, by:

performing a stack current check;

performing a stack voltage check; and

performing a cell voltage check, on a predefined schedule during normal operation of the fuel cell system.

17. The computer-readable media of claim 16, having instructions for causing the microcontroller to operate the fuel cell system, further by:

performing an oxygen concentration check; and

performing a hydrogen concentration check.

18. The computer-readable media of claim 16, having instructions for causing the microcontroller to operate the fuel cell system, further by:

performing a stack temperature check.

19. The computer-readable media of claim 16, having instructions for causing the microcontroller to operate the fuel cell system, further by:

performing an ambient air temperature check.

20. The computer-readable media of claim 16, having instructions for causing the microcontroller to operate the fuel cell system, further by:

performing a purge check.

21. The computer-readable media of claim 16, having instructions for causing the microcontroller to operate the fuel cell system, further by:

performing a fuel pressure check.

22. The computer-readable media of claim 16, having instructions for causing the microcontroller to operate the fuel cell system, further by:

performing an air flow check.

23. The computer-readable media of claim 16, having instructions for causing the microcontroller to operate the fuel cell system, further by:

performing a microcontroller self-check.

24. The computer-readable media of claim 16, having instructions for causing the microcontroller to operate the fuel cell system, further by:

toggling a watchdog timer.

25. A method of operating a fuel cell system, comprising:

performing a stack current check at a first frequency; and

performing a stack voltage check at a second frequency, the second frequency equal to half the first frequency.

26. The method of claim 25, further comprising:

performing a cell voltage check at the second frequency.

27. The method of claim 25, further comprising:

performing a purge cell check at a frequency equal to one quarter of the first frequency.

28. The method of claim 25, further comprising:

performing an oxygen concentration check at a frequency equal to one twentieth of the first frequency.

29. The method of claim 25, further comprising:

performing a hydrogen concentration check at a frequency equal to one twentieth of the first frequency.

30. The method of claim 25, further comprising:

performing a stack temperature check at a frequency equal to one twentieth of the first frequency.

31. The method of claim 25, further comprising:

performing an ambient air temperature check at a frequency equal to one twentieth of the first frequency.

32. The method of claim 25, further comprising:

performing a fuel pressure check at a frequency equal to one twentieth of the first frequency.

33. The method of claim 25, further comprising:

performing an air flow check at a frequency equal to one twentieth of the first frequency.

34. The method of claim 25, further comprising:

performing a hydrogen sensor heater check at a frequency equal to one twentieth of the first frequency.

35. The method of claim 25, further comprising:

performing a battery voltage check at a frequency equal to one twentieth of the first frequency.

36. The method of claim 25, further comprising:

performing a microcontroller self-check at a frequency less than the first frequency.

37. The method of claim 25, further comprising:

toggling a watch dog at a frequency equal to one twentieth of the first frequency.

38. A method of distributing load on a microcontroller in a fuel cell system, comprising:

dividing a time period into twenty slots, during which up to four tasks can be executed by the microcontroller;

scheduling a stack current checking routine to each of the twenty slots;

scheduling a stack voltage checking routine to every other slot of the twenty slots; and

scheduling a cell voltage checking routine to alternate ones of the slots from the stack voltage checking.

39. The method of claim 38, further comprising:

scheduling a purge cell checking routine to every fifth slot of the twenty slots.

40. The method of claim 38, further comprising:

scheduling a watchdog toggling routine every fifth slot of the twenty slots.

41. The method of claim 38, further comprising:

scheduling a stack temperature checking routine in one of the twenty slots;

scheduling an oxygen concentration checking routine in another one of the twenty slots; and

scheduling a hydrogen concentration checking routine in another one of the twenty slots.

42. The method of claim 38, further comprising:

scheduling a fuel pressure checking routine in one of the twenty slots;

scheduling an ambient air temperature checking routine in another one of the twenty slots;

scheduling an air flow checking routine in another one of the twenty slots; and

scheduling a hydrogen sensor heater checking routine in another one of the twenty slots.

43. The method of claim 38, further comprising:

scheduling a microcontroller self testing routine in one of the twenty slots; and

scheduling a battery voltage checking routine in another one of the twenty slots.

44. The method of claim 38, further comprising:

performing the scheduled acts.